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Dwarf Elliptical Galaxies in the Perseus Cluster

J.S. Gallagher (1), C.J. Conselice (1), R.F.G. Wyse (2)

1. *U. Wisconsin-Madison*, 2. *Johns. Hopkins U.*

Abstract.

Dwarf ellipticals have the lowest stellar densities of any galaxies, but paradoxically are most common in the densest regions of the universe, and are especially frequent in rich clusters of galaxies. Simple estimates suggest that low luminosity dwarf ellipticals should be subject to substantial tidal heating in rich clusters if most of their mass is in the form of normal stars. We have therefore undertaken a program to image dwarfs in clusters with the 3.5-m high performance WIYN and ARC and smaller, wide field telescopes. Our objectives include testing for evidence of tidal disruption in the form of asymmetries and searching for evidence of recent star formation which might be associated with the production of elliptical dwarfs from infalling field galaxies.

1. Overview

Dwarf elliptical galaxies appear in abundance in galaxy clusters containing strong gravitational tides. These low luminosity, low surface brightness objects dominate clusters by number, giving them very steep luminosity functions. A basic question to ask is: where did these dwarfs come from, and how can they survive in rich clusters? Also, what is the relationship between the formation and evolution of giant galaxies and dwarfs?

To help answer these questions, we obtained images of Perseus, a rich galaxy cluster with a radial velocity of 5500 km/s ($D=75$ Mpc w/ $H_0 = 75$ km/s/Mpc). Morphological identification of dEs is tricky, and most previous studies pick their dE sample based on colors, typically $1.2 < (B-R) < 1.6$. However, given the relative proximity of Perseus, it is possible to reverse this procedure - that is, to determine morphologically the dE sample, and then derive physical properties on this morphological selected sample.

Our major preliminary conclusions for this study are:

- Dwarf candidates in Perseus appear to have a wide range of colors, making any simple, one time formation scenario unlikely.
- We find the dEs, including the nucleated dEs (dE,N), are consistently the same color throughout the dwarf. This indicates the stellar populations are likely homogeneous in these dwarfs.

A Perseus cluster field of 35 kpc x 35 kpc showing the high number of dwarfs from a WIYN R-band observations is presented in Figure 1. We are able to identify 85 candidate dEs in our Perseus cluster images. This gives a number density of 1000 dEs/Mpc². The basic properties of the dwarfs in Perseus are as

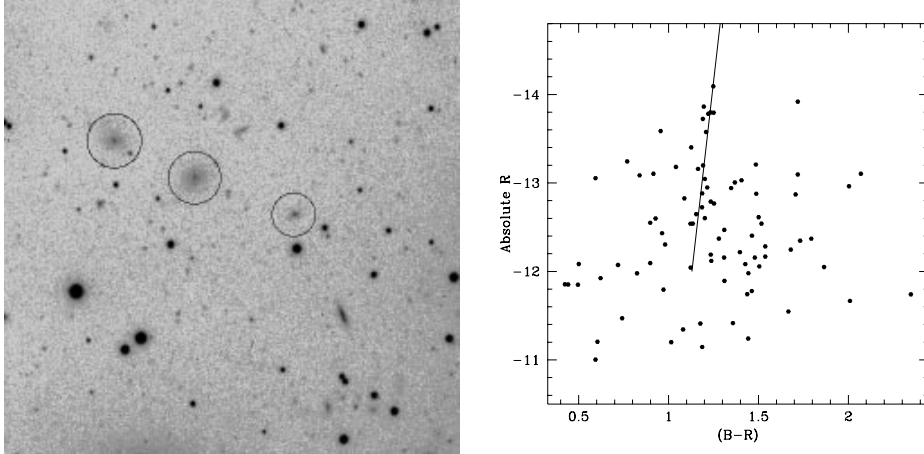


Figure 1. Examples of Perseus cluster dEs from a WIYN image, and our preliminary dE CMD.

follows: Absolute Magnitude range : $-14 < M_R < -11$, colors : $0.67 < (B-R) < 2.6$, and central surface brightness: $22 < \mu_R < 25$.

The surface brightness, and magnitudes are standard, and agree with other observations of dwarf ellipticals, but the colors of dEs in Perseus cover a wide range. There is a slight correlation between the absolute magnitude of the brighter dEs in Perseus and the $(B-R)$ color (Figure 2). The line in Figure two is the relationship found between $(B-R)$ and magnitude for dEs in the Coma cluster by Secker et al. (1997).

Nucleated dEs are a well established morphological sub-class, and appear as bright dEs with a concentrated center. These nucleated cores are generally believed to be super massive star clusters that are usually about 50 pc in size. The color of these nucleated cores have typically been found to be indistinguishable from the remainder of the galaxy. We verify this for the Perseus dEs.

What are the origin of these dEs? Following Merritt (1984) galaxies in clusters are subject to long term tidal forces from the cluster core; typically $\approx 10^{14} M_\odot$ within a radius of 200-300 kpc. These should tidally truncate extreme dE dwarfs at $R \sim 3-10$ kpc; we find the largest dEs in Perseus and Coma to be about this size. Tides therefore may control dE sizes near cluster cores. Likewise, galaxies on high eccentricity orbits cross a cluster core in a time comparable to internal orbital periods for stars in their outer envelopes. These systems may experience tidal shocking, resulting in dynamical heating of the dwarf and possibly removal of mass. Collisions from impact approximation models predict episodic heating and some mass loss. Sometimes collisions will occur with low relative velocities; these can be more damaging, and possibly produce dEs with a range of colors from small disk galaxies.

References

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